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Fabrication and Brownian Diffusion of Boomerang Colloidal Particles

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1 Introduction

Boomerang is ubiquitous as molecular shapes that may form various kinds of liquid crystalline phases. One controversial topic related to boomerang molecules is the existence of biaxial nematic liquid crystalline phase. Developing and studies of boomerang shaped colloidal suspensions may allow us to gain better understanding of both their orientation ordering and dynamics at "single molecule" level. Here we report the fabrication and experimental studies of the Brownian motion of individual boomerang colloidal particles confined between two glass plates.

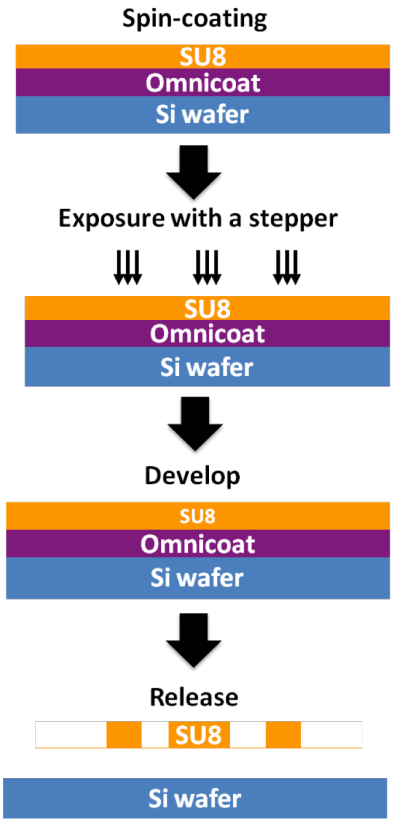

Fig. 1. Schematics of fabrication process flow for the boomerang particles.

2 Fabrication & Experimental Techniques

We adapted a top-down fabrication procedure to fabricate polymeric boomerang-shaped colloidal particles (Fig. 1) [1]. Through photolithographic patterning of polymeric photoresist, this method allows for mass production of various 3D shapes that can be designed at will. The process flow for the fabrication is shown in Fig. 1. In the first step a 4 inch silicon wafers is spin coated with a sacrificial layer of Omnicoat which is a water soluble polymer. Next a negative photoresist SU8 is spin coated on the sacrificial layer producing a layer thickness of 600nm. The SU-8 coated wafer is exposed to a pattern of UV light using a 5× reduction Autosteper. To pattern the UV we use mask containing

prototypes of the boomerang particles. Next the wafers are developed using SU-8 developer which is an organic solution that does not attack the sacrificial release layer but removes the un-cross linked SU-8 resist which is unexposed to the UV leaving the cross linked SU-8 polymer boomerang particles. In the last step of the fabrication process the sacrificial layer is dissolved by agitation in PG remover of Omnicoat stripper, causing the particles to detach from the wafer and dispense into the solution. After liftoff, the particles are stabilized using a surfactant-salt solution. The particles are then centrifuged and the solution is replaced with DI water and suspended in cells of different thicknesses. An EMCCD was used to capture the motion in real time. An indigenously developed imaging processing algorithm based on MatLab program was used to precisely track the position and orientation of the particles with sub-pixel accuracy for the study of Brownian motion.

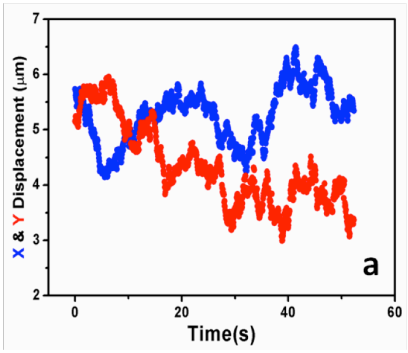

Fig. 2. Random displacements in the lab frame as a function of time.

3 Results

The Brownian motion of a single boomerang particle is marked by random displacements in the X and the Y direction as shown in Fig. 2. The displacement in the lab frame is measured by analyzing the video frame by frame. The corresponding displacements in the body frame are calculated by coordinate transformation. To calculate the mean square displacements we make an ensemble average of different trajectories starting at different time t_0 but ending after same time interval t. The experimental and theoretical results on translational and rotational diffusion will be presented and discussed.

References

[1] Hernandez, C. J. and Mason, T. G, Journal of Physical Chemistry C, 2007. **111**(12): p. 4477-4480.